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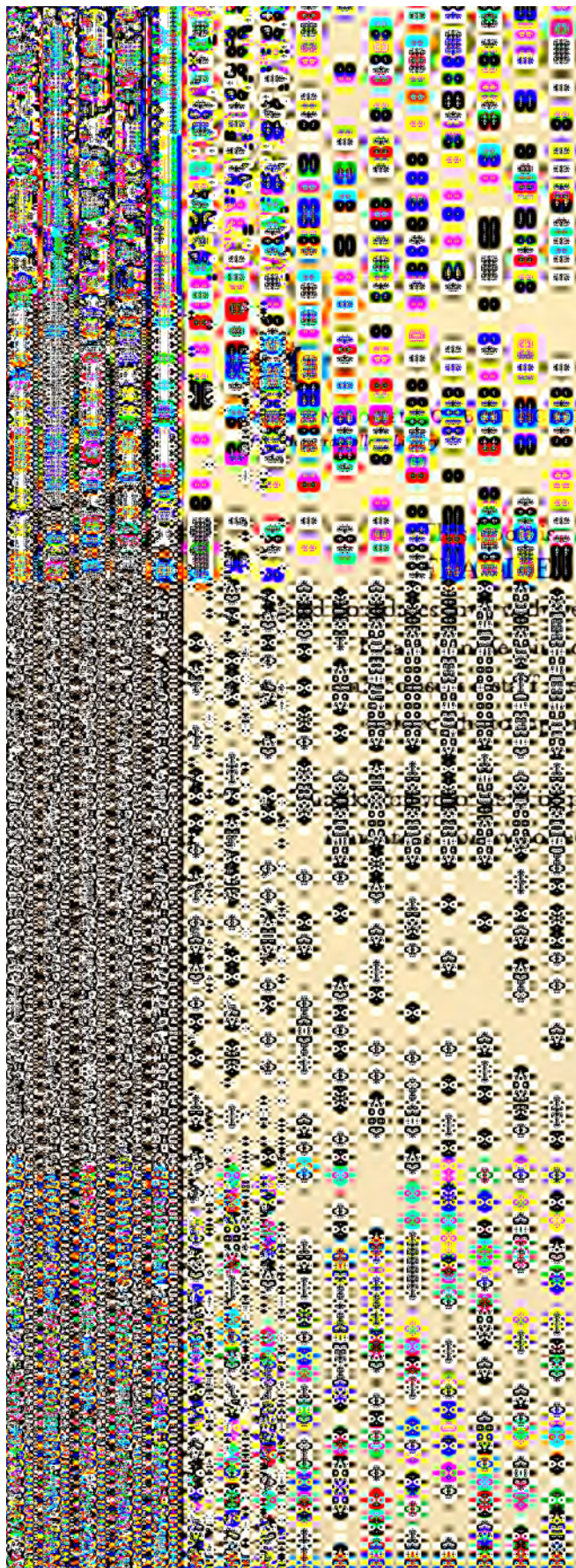
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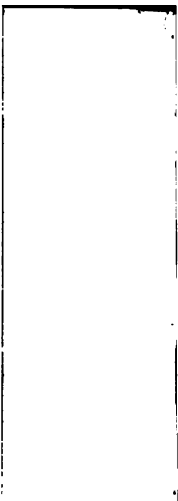
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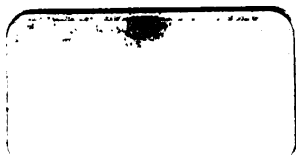
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... THE ...

Compromise Standard System

OF

Live Loads for

Railway Bridges

AND

THE EQUIVALENTS FOR SAME.

By J. A. L. WADDELL,
CONSULTING BRIDGE ENGINEER,
KANSAS CITY, MO.

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Engineering

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- PL. II. Diagram of Live Load End Shears on Plate Girder Spans.
- PL. III. Diagram of Equivalent Uniform Live Loads for Plate Girder Spans.
- PL. IV. Diagram of Equivalent Uniform Live Loads for Truss Spans.

PREFACE.

The various steps taken in the preparation of this pamphlet were as follows:

About two years ago the author presented to the American Society of Civil Engineers a paper entitled, "Some Disputed Points in Railway Bridge Designing," in which he advocated the adoption of a few standard train loads for railway bridges instead of the almost innumerable ones then in use, offered a set of loads for discussion, and urged that the "Equivalent Uniform Load Method" of computing stresses be adopted instead of the burdensome method of wheel concentrations that has been in vogue for the last ten years. This paper received a very thorough discussion, and from the same it was evident that bridge and railway engineers as a whole would be glad to settle upon a few standard loadings, and to adopt some simple equivalent method of computing stresses. Most of those who desired the abandonment of the "Concentrated Wheel Load Method" advocated the adoption of the "Equivalent Uniform Load Method," but a few favored the "Single or Double Concentration Method" with a constant car load.

This paper with the discussions was published in the February and March, 1892, number of the *Transactions* of the American Society of Civil Engineers, and was reviewed very generally by the technical press, attention being paid principally to the subject of equivalent loads. These reviews started a series of letters, principally by the author, printed at first in the *Railroad Gazette*, and later also in the *Engineering Record*, in which the subject of equivalents was thoroughly and exhaustively treated, the effect thereof being to prove that the "Equivalent Uniform Load Method" gives results which are accurate enough for all practical purposes, and that neither the "Single Concentrated Load Method" nor the "Double Concentrated Load Method" gives results coinciding at all closely with those found by the theoretically exact method of "Wheel Concentrations."

In November, 1892, the author sent a circular letter to all the chief engineers of railroads in the United States and Canada who are

members (in any grade) of the American Society of Civil Engineers, and to every other member of that society connected with or specially interested in the designing, building or operating of railroad bridges. This letter solicited a ballot on certain "Disputed Points in Railway Bridge Designing," foremost among which were those of standard live loads and a simple equivalent method of computation. The number of responses received was as great as could have been expected; and the result was that about eighty-two per cent. of those who voted were in favor of adopting a "Standard System of Live Loads for Railway Bridges" similar to that proposed by the author, and eighteen per cent. were opposed to same; and eighty-two per cent. of those who voted were in favor of abandoning the "Concentrated Wheel Load Method" and eighteen per cent. were in favor of retaining it. Of the former, seventy-eight per cent. favored the "Equivalent Uniform Load Method," and twenty-two per cent. were in favor of either the "Single or the Double Concentration Method." A number of gentlemen who responded made valuable suggestions in respect to the standard system of live loads propounded, and by the aid of these the author prepared a proposed "Compromise Standard System of Live Loads for Railway Bridges," and submitted the same as before for a final ballot in May, 1893.

The number of replies received showed that great interest was taken in the question; and the result of the ballot was ninety per cent. in favor and ten per cent. opposed to the proposed standard.

In accordance with the promises made in the circulars and letters before mentioned, the author herewith presents to the civil engineering profession the following curves of total end shears on plate girder spans and of equivalent uniform loads. A number of complimentary copies of this pamphlet will be distributed in the immediate future, after which it will be for sale by *Engineering News*.

J. A. L. W.

KANSAS CITY, MO.

September 1, 1893.

METHOD OF UTILIZING THE EQUIVALENT LOADS.

In calling for bids on bridge work to be accompanied with designs for the structures, a railroad engineer can nominate any bridge specifications whatsoever, standard or otherwise, and at the same time specify that the live loads are to be taken from the "Compromise Standard System," and that the "Equivalent Loads" thereof are to be employed.

In this "System" will be found from "Class Z" to "Class U," inclusive, a close approximation to any live load that an engineer is likely to want to use; and if, for a certain car load, some engineer should prefer a heavier or lighter engine loading, he can obtain practically what he wishes by specifying that one class is to be used for floor systems and primary truss members, and another class for main truss members. The author does not advise this, however, except in the case of double track bridges, where it would be advantageous to use a certain class for floor systems and primary truss members and a lighter class for the trusses, because the chances of there being two, full, maximum train loads on the span at the same time are generally very small. It might be well to carry this idea even further by specifying, for instance, "Class V" for stringers, "Class W" for floor-beams and primary truss members, and "Class X" for main truss members of double track bridges. Such a method would be in accordance with the theory of probabilities. Said theory, however, would not apply to single track bridges, for which the locomotive and car loads of the "Compromise Standard System" have been properly adjusted.

The "Equivalent Uniform Load Method" reduces to a minimum the labor of making computations of stresses in bridges. The correctness of this statement will be rendered evident by the ensuing explanations of the use of the method. As for its exactness, if anyone has any doubt whatsoever about its closeness of approximation to the theoretically correct method of wheel concentrations, let him read the

author's letter in the *Railroad Gazette* of July 28, 1893. An inspection of Table I. of that communication shows that no reasonable man can object to the "Equivalent Uniform Load Method" because of its want of exactness.

In designing a bridge, one commences naturally with the stringers, then passes to the floor-beams and afterwards to the trusses, so let us follow this order.

STRINGERS.

From Plate III. find the equivalent live load per lineal foot for a span equal to the panel length, add to same the assumed weight per foot of two stringers and the floor they support, and divide the sum by two, calling the result w ; then to find the total bending moment at mid-span, substitute in the well known formula,

$$M = \frac{1}{8} w l^2$$

where l is the panel length in feet, and M the required moment in foot-pounds.

Should the total end shear be required, it can be found for each stringer by adding together the end shear given on Pl. II. and the total weight of one stringer with the floor that it carries, and dividing the sum by two.

FLOOR-BEAMS.

In proportioning a floor-beam, the important thing to ascertain is the total concentration at the point where two stringers meet. The live load concentration is to be found by multiplying together the panel length and the equivalent uniform load per lineal foot given on Pl. III. *for a span equal to twice the panel length*, and dividing the product by two. It is unnecessary to describe here how the dead load concentration at each stringer support is to be found. Nor is it necessary to do more than merely mention that the live load concentration obtained for the floor-beam is the same as that required in finding total stresses in primary truss members.

TRUSSES.

These can be divided into two kinds, viz., those with equal panels and parallel chords, and those in which the panel lengths are unequal, or the chords are not parallel, or both. In the first case the stresses

can be determined most expeditiously by substitution in tabulated formulæ, and in the second case by the graphical method.

CASE I.

From Pl. IV. find the equivalent uniform live load per lineal foot for the given span length and multiply same by the panel length, calling the product L . For single track bridges this must be divided by two. All the live load stresses in main truss members of single intersection bridges can be found by substituting this value of L in the table given in Carnegie's Pocket Companion (p. 211 of the 1892 edition), and in other treatises on bridges.

Just here it is proper to remark that the "Equivalent Uniform Load Method" is not applicable to trusses of multiple intersection; but that the most approved modern practice in bridge engineering does not countenance the building of trusses or girders having more than a single system of cancellation. The "Equivalent Uniform Load Method" does, however, apply to trusses with divided panels, such as the Pettit truss; but as this style of truss now-a-days involves almost invariably a broken top chord, its treatment herein will come under

CASE II.

Where trusses have unequal panels or chords not parallel, the first step to take is the finding of all the dead load stresses by the graphical method, starting from one end of the span and working towards the middle, where the last stress is checked by the method of moments, and the correctness of the entire graphical work is thereby proven.

The next step is to find from Pl. IV, as in Case I, the equivalent live load per lineal foot for the span, and therefrom the value of the panel-truss live load L . Next set a slide rule for the ratio of dead load per lineal foot and the equivalent live load per lineal foot for the span, and, by referring to the dead load stresses already found, read off from the rule all of the live load stresses in chords and inclined end posts.

Next assume that there is an upward reaction at one end of the span equal to 1,000 pounds, 10,000 pounds or 100,000 pounds, (ac-

cording to the size of the bridge), caused by a load placed at the first panel point from the other end of the span, then find graphically the stress in each web member from end to end of span, caused by this assumed upward reaction. Then calculate the value of the live load reaction for the maximum stress in each web member by means of the slide rule and the following formula and table in which n is the number of panels in the span; n^1 is the number of the panel point at the head of the train, counting from the loaded end of the span, and C is the co-efficient of $\frac{L}{n}$.

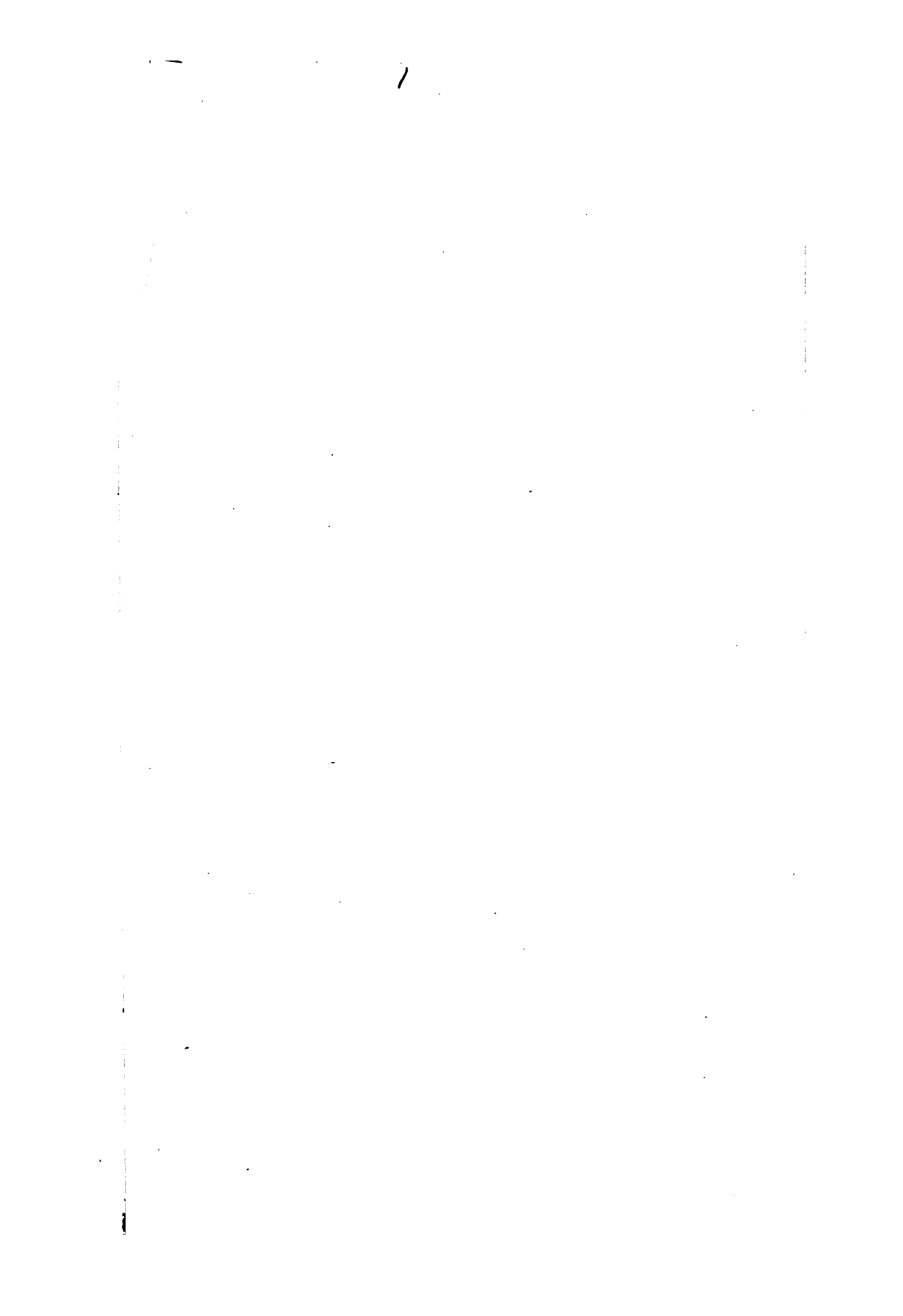
Live Load Reaction for head of train at $n^1 = C \times \frac{L}{n}$.

n^1	C	n^1	C	n^1	C	n^1	C
1	1	7	28	13	91	19	190
2	3	8	36	14	105	20	210
3	6	9	45	15	120	21	231
4	10	10	55	16	136	22	253
5	15	11	66	17	153	23	276
6	21	12	78	18	171	24	300

Then, still using the slide rule, find the greatest live load stress in each web member by the following equation :

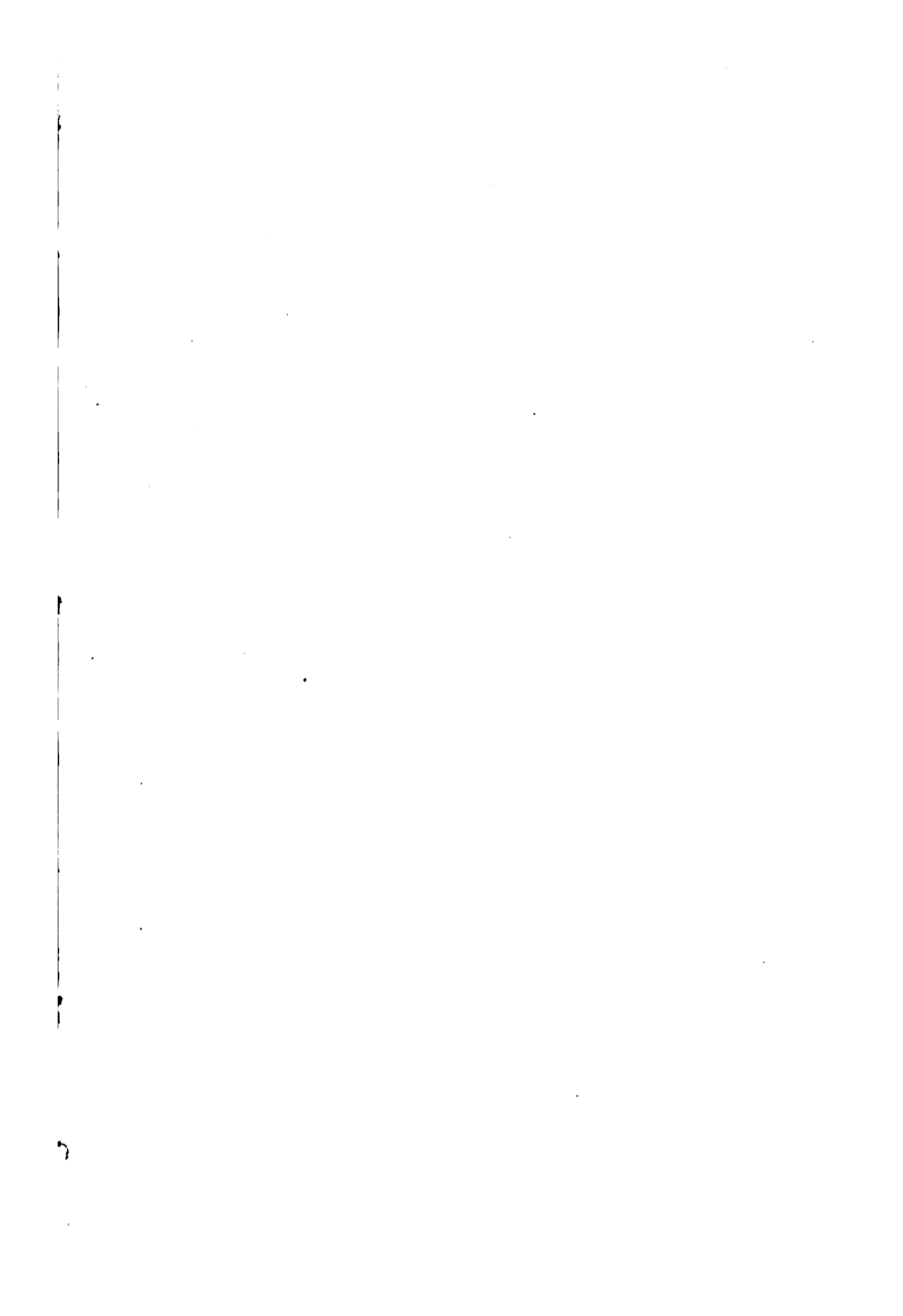
$$\text{Stress required} = \text{Stress from Assumed Reaction} \times \frac{\text{Actual Reaction}}{\text{Assumed Reaction.}}$$

Where the panels are divided as in the Pettit truss, and where inclined sub posts are employed, the *tensile* stress in the *upper* half of each main diagonal thus found will have to be corrected by subtracting therefrom a stress equal to $\frac{L}{2}$ sec. A , where A is the inclination of the diagonal to the vertical. But when inclined sub ties are used instead of inclined sub posts, the correction just referred to will apply only to the *compressive* stresses in the *lower* halves of the main diagonals. The reason for making this correction, as will be at once evident to anyone who is accustomed to finding stresses in Pettit trusses, is that the method above outlined ignores the subdivision of the panels when ascertaining by graphics the stresses caused by the assumed upward reaction.





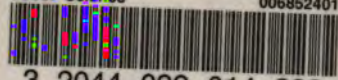




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